Cost of the Program

The leadership in Communist China has given the highest priority to the development of modern, especially advanced, weapons. Current expenditures for military and military-related activities may be running in the neighborhood of 10 percent of GNP, a somewhat higher share of GNP than in France and the UK -- countries that each have a larger total output than China but less than one-fifteenth the population. The cost of the weapons program is not as important as the fact that it uses manpower and materials of the highest quality that otherwise could be used to build up the civilian sector of the economy. For example, the relatively large quantities of specialized resources -- scientists, design engineers, highly trained technicians, and high-quality materials and machinery components -- required by the modern weapons program hinders the expansion of the chemical industry and therefore limits the supplies of chemical fertilizer for agriculture. Chou En-lai noted these costs when he indicated in a conversation with visitors in November 1964 that China's pursuit of a nuclear capability had imposed an enormous burden on the economy.

Because China almost certainly will not receive technical assistance on the scale that it did during the 1950's, and because the contribution of agriculture to economic development will be less

than it was in the decade of the 1950's,* development of the industrial base in the next 5 to 10 years probably will be at a much slower rate and will be centered on a narrower group of industries. In those fields related to the advanced weapons program, however, the high priority in the allocation of scarce resources may yield notable improvement in technological capabilities.

The economic burden acknowledged by Chou En-lai will become far more pronounced as China attempts to move various weapons systems from the development to the production phase. Moreover, for the Chinese as for any other country, the production of nuclear warheads will not prove to be as expensive as the development, deployment, and maintenance of even a relatively crude delivery system or systems, including aircraft. The inevitable rise in costs associated with the production phase of even a modest effort probably has forced (or will force) the Chinese Communists to channel their efforts at any one period of time into the development of only a very limited range of delivery systems, such as an SS-4 type of ballistic missile. The rise in costs associated with moving from the R&D phase into large-scale series

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* Unless, and until, the agricultural sector in China receives sustained large-scale increases in inputs, the food situation probably will remain precarious, and the country will tend to hover unsteadily on the brink of another food crisis. Should another food crisis occur, it would probably slow down both industrialization and the advanced weapons program. However, the Chinese would make great efforts to keep the latter area at least as well insulated as it obviously was during the very difficult period of late 1960 to early 1962.

production results from ballooning requirements for inputs of specialied material, equipment, and technical manpower.* The lack of resources available from the slowly growing Chinese industrial base almost certainly will preclude the simultaneous development of other systems that might complement each other militarily and be highly desirable to the Chinese Communists.

Although costs will rise significantly for those individual weapons systems that are moved into series production, overall investment in the military industries may not rise proportionately, because only a few weapons systems probably will be carried to the production stages during the next several years. In addition, developmental costs probably have been (and will continue to be) reduced for China to the extent that it has been able to take advantage of R&D expenditures previously borne by the USSR.

Technical Manpower

One of the scarcest resources for Communist China is skilled manpower. Although China has an abundant supply of unskilled labor, it is faced with an acute shortage of technical/scientific, managerial, and skilled personnel. In recent years a high priority reportedly has been given to increasing the level of scientific and technical skill

* Production costs, relative to costs incurred in R&D, are likely to be higher in China than in a country such as the US or even France because of the greater need to build up supporting industrial facilities and technical know-how, which already exist in more industrially

needed in support of favored industrial sectors such as advanced weapons, petroleum refining, and chemical fertilizer. Nevertheless, the number of Chinese who have received graduate training in the physical sciences at local institutions probably amounts to only a few hundred, although the number is scheduled to grow. Thus most of China's best technical talent probably continues to be those who were educated abroad.

Requirements

The exact magnitude of China's overall requirements for technical manpower is unknown. It is probable, however, that these requirements have been compounded since 1960 both by the withdrawal of Soviet technical support and by the increased diversion of the best trained and experienced people into support of the country's advanced weapons program. The total number of scientific/technical personnel assigned to the latter area is unknown, but some indication of the magnitude can be obtained from the number involved only with the nuclear program.

Because of the problem of substitutability,* it is virtually impossible to estimate the range and quantities of industrial

* China may be able to produce one product, such as high manganese steel, that would be satisfactory on a "make do" basis for a number of the same critical applications as a certain type of "needed" stainless steel that China cannot produce.

material inputs needed for a nuclear program. However, studies have estimated the numbers and kinds of persons required. One relatively recent study estimates that the technical and scientific manpower required for a nuclear effort roughly similar to China's amounts to about 475 scientists (150 physicists and 325 chemists), 125 metallurgists, and approximately 1,200 assorted engineering specialists.*

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the actual number of Chinese scientists and engineers involved in the nuclear program may range from as few as 300 to as many as 1,000, suggesting that the independently calculated figures cited in the study probably are of the correct order of magnitude. The numbers of personnel in the study relate only to those professional people associated with research and development, design, construction, operation, and bomb testing. If the engineers and scientists needed for related activities, such as production of raw materials and finished industrial products for the nuclear facilities, are included, the number could be doubled. Large numbers of technically skilled workers also are required at all stages.

Elsewhere in the economy, a relatively large but unknown number of scientific/technical personnel must also be involved in development work associated with related delivery systems and modern

* By way of comparison, the Los Alamos Scientific Laboratory, where the first US bomb was produced, employed a peak of 3,000 scientists

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conventional weapons. In addition, substantial numbers are assigned to the civilian industrial sectors, particularly the high-priority chemical and petroleum industries.

Availability

Chinese Educated Domestically

The quality of the training received by technical students in China varies considerably with the period in which they were trained. Those who graduated between 1949 and 1954 tended to be poorly trained because of the unsettled conditions in the country during that period. The graduates with the highest quality of training probably are those who received their training between 1954 and 1958, when educational programs were firmly established and Soviet advisers imposed strict academic regulations. During the "leap forward", however, the educational system was disrupted by pressure on students, teachers, and members of research institutes to attend political meetings, to participate in labor, or to undertake other academically nonproductive activities. In 1962 these pressures began to be relaxed, and education and research began to return to the status prevailing during 1954-58. In particular, efforts were made to maximize the utility of the small existing supply of technical manpower by relaxing many of the diversionary pressures.* In addition, the regime has taken

* The senior scientific/technical personnel as well as college students in the physical sciences are believed to have been exempted

steps to insure that "special treatment is accorded by the State to bourgeois scientists and experts," including the provision of small Western-style houses and small cars.

Since the Communist takeover, more than 1,350,000* students have been graduated from Chinese universities and colleges, of whom about 800,000 specialized in scientific and technical subjects, including medicine and public health. These figures are not true indicators of China's R&D capability, however, because the average quality of the graduates is not high and many have had only a few years' experience. According to official claims, China has "only several thousand higher scientific and technical personnel," including foreign-trained returnees and the few hundred who have been trained domestically to the doctorate level.

The official statements, and even in journals dealing with science and scientific affairs, there is a marked absence of specific reference to research personnel. The reason for this omission is not clear, but it seems likely that the regime is being deliberately secretive about the numbers of qualified research scientists because of defensive feelings about the inadequancy of the size of the Chinese research community.

Very slow progress is believed to have been made in overcoming the critical shortage of scientists** capable of doing

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advanced work (planning and directing research), but programs currently under way suggest that the rate of increase in the numbers of such personnel may rise somewhat during the late 1960's. Through 1970 the formal training programs may add 3,000 new scientific/technical people who have had four years of graduate training.

Chinese Educated Abroad

About 3,000 Chinese have been educated to the doctorate level abroad (both in the West and the USSR) and probably are an important source of manpower inputs into China's R&D activities. A compilation made in mid-1965 indicates that approximately 147 Chinese physicists, 313 chemists, and 90 metallurgists were educated outside of the country (three-fourths of them to the doctorate level)* and are known to have returned to China. With respect to returnees in these three fields, most of those trained in the West (60 percent of the total) had returned by 1960, whereas most of the Soviet-trained returned during 1960-63.

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* The Soviet Kandidate degree in the physical sciences is comparable to the Ph.D. and other doctorates in the West.

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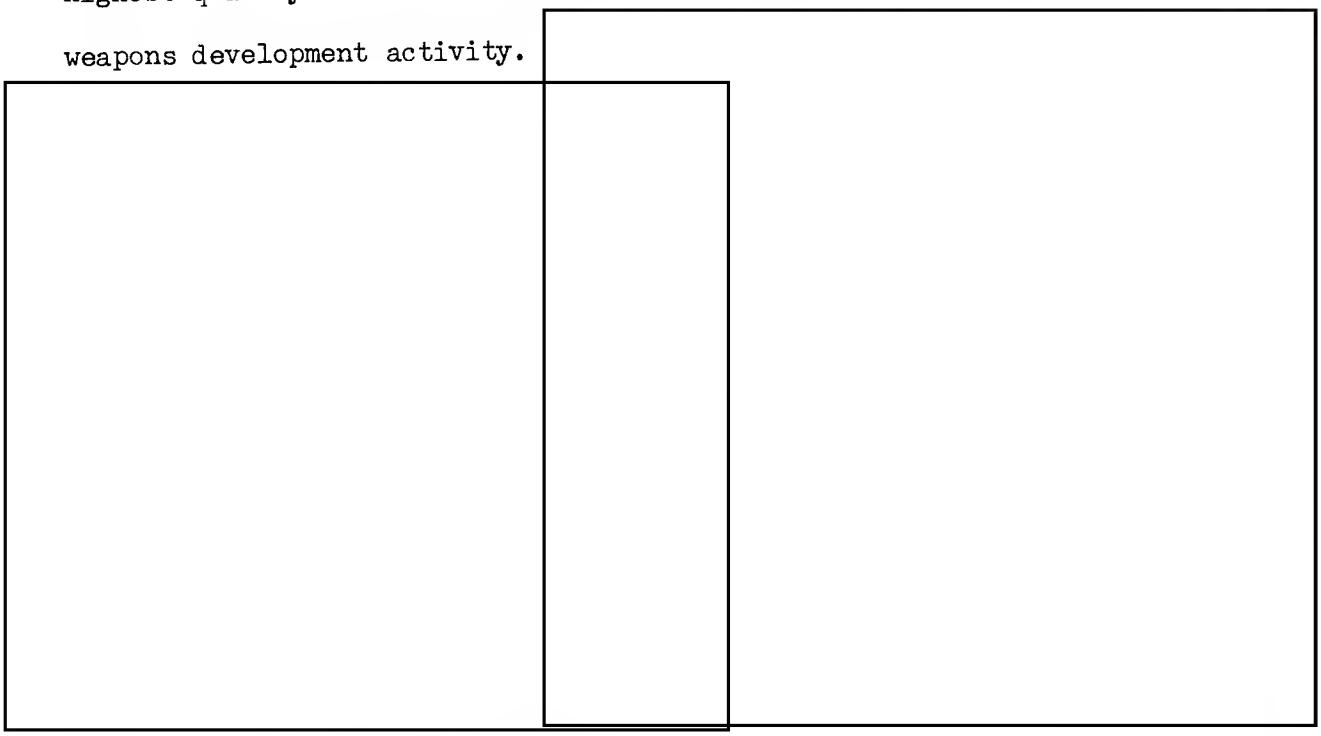
A comparison of the number of returnees in these three technical categories with the number required for China's nuclear effort indicates that the country probably has an adequate supply at least for the leadership in research associated with the program. When allowance also is made for the relatively large number probably involved in developing other weapons systems (both advanced and modern conventional weapons) it seems likely that a very large portion of China's highest quality technical talent has been assigned to some phase of weapons development activity.



Foreign Assistance

Since 1963, in a break with its traditional policy of relying on support from other Communist countries, China has been turning to the Free World for technical assistance, including exchanges

of scientists, students, and teachers with the West* in addition to the purchase of at least 20 complete industrial plants and the collection of technical publications. In an effort to fill the gap left by the withdrawal of Soviet technicians and the drying up of both the supply of Soviet technical data and scientific and technical cooperation between the two countries, a small but increasing number of Chinese Communist scientists and technicians have visited Western laboratories and plants. In addition, Chinese attendance at international scientific and technological meetings outside the Bloc has increased. In turn, Free World scientists have visited Chinese laboratories and have given lectures on specialized subjects, including stainless steels, physics, and chemistry.

The Chinese have increased their efforts to collect foreign publications in widespread areas of science and technology, and students have been encouraged to study English and other Western languages. In addition, new language schools have been established at Shanghai, Peiping, and Tsinan, and a small number of Free World language instructors have been sent to China.

To the extent that assistance by the Free World expands the technical resources, including manpower, available to China it will ease the burden on the civilian economy of the top-priority

* An education exchange pact signed with East Germany in July 1965 may mark a reversal of the trend that has prevailed since 1960. The agreement may indicate a decision to renew exploitation of training opportunities within the Communist world while at the same time avoiding a display of dependence on the USSR.

allocation of resources to military programs. Such assistance will provide small but probably important additions to technical know-how in a few civilian industrial areas. Furthermore, it will meet (and in some instances already has met) a few critical requirements for both material and technological capabilities needed in military production, including the programs for advanced and modern conventional weapons.

The acquisition of foreign technical publications and technical training, along with various types of exchanges with Free World countries, will help to improve the level of Chinese technical training and overall technology. Nevertheless, the effect of assistance from the West on the supply of highly skilled scientists and technicians who can plan and conduct advanced research is likely to be small. To overcome this central problem in science and technology, China probably will need the advice and assistance of foreign experts for a number of years to come.

Conclusions

In the absence of extensive external assistance, it is likely that over the next several years the number of advanced military and/or industrial programs undertaken will continue to be few because of the shortage of competent senior scientific/technical talent in China. The regime does have sufficient technical manpower to make progress toward almost any relatively narrow objective, but only at the expense of very slow progress in alternative areas. Thus the establishment of priorities and the allocation of scientific manpower so as to

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maximize benefits are among China's most pressing problems. The assigning of the most competent people to the nuclear and advanced weapons program has had the inevitable result of reducing the efficiency of those areas from which such personnel have been taken and of causing direct and indirect burdens elsewhere in the economy.

In the short run the effect probably has been a serious retarding of the development and introduction of new native civilian industrial technology on a broad scale. For example, two of the country's largest steel mills have been crippled since the Soviet withdrawal five years ago, because of the apparent inability of the Chinese to design and manufacture large-capacity precision rolling mills. This retardation has occurred even though some benefits probably have accrued to the civilian industrial sector in the form of some technological processes or new materials coming out of China's military R&D effort.

In the longer run, China's goal of achieving near technical/scientific parity with the West by the late 1960's, as was called for in the 12-year plan for scientific development adopted in 1956, probably has been delayed for an indefinite period.* Under the best of conditions the 12-year plan could have been achieved only if (a) the USSR had continued its aid after 1960 and (b) the majority of

* The 12-year plan (1956-67) was replaced by a 10-year plan (1963-72) during 1963; however, no details are available as to its content.

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China's highest quality personnel had been permitted to make teaching their main activity. Neither occurred. Furthermore, the diverting of the best scientific people away from college-level teaching into military R&D will mean that new scientists capable of doing independent technological and scientific work will not be trained. It is conceivable that by continuing to push the military program (particularly advanced weapons) on a crash basis, China will have fewer highly trained men in R&D within a few years than it would have had if new scientists and engineers had been trained by those in teaching and had themselves been spared from nonteaching assignments. The most critical bottleneck in the expansion and improvement of education in China is the shortage of excellent teachers. Unless enough of the country's ablest manpower is reinvested in education (or is supplemented by foreign assistance), China's human resources will remain underdeveloped and shortages of specialized manpower in many industrial fields will increase. Studies have shown that in the US, for example, in order to staff the colleges and universities adequately, one-half of the annual crop of doctorate-level scientists and engineers must enter academic careers. In China the percentage probably would be higher.